GRI 79-1-E

GEOTHERMAL LOGGING INSTRUMENTATION DEVELOPMENT PROGRESS REPORT

September

Sandia Laboratories
GEOTHERMAL TECHNOLOGY

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GEOTHERMAL LOGGING INSTRUMENTATION DEVELOPMENT PROGRESS REPORT
SEPTEMBER 1979

Summary

Progress

* Evaluation of the first 275°C voltage regulators delivered by Teledyne Philbrick has begun. Teledyne delivered 50 units to Sandia; testing is being performed with the aid of microprocessor based testers and laboratory ovens. Thus far, the units' short-term stability and output voltage temperature coefficient are within specification.

* The 4000 pF capacitors have been successfully fabricated for the Teledyne Philbrick voltage-to-frequency converter hybrid circuit. The capacitors are stable in that they changed less than ± 1.5% between room temperature and 300°C.

* The Sandia exhibit of high temperature components and hybrid circuits was well received at the annual Geothermal Resources Council Meeting in Reno, Nevada, during September 24-26, 1979. A high percentage of attendees requested purchase information for the display items. Such interest indicates a ready market for commercialization.

* Development of a 300°C integrated circuit, operational amplifier (op amp) is underway at Harris Semiconductor under a Sandia contract. This 300°C op amp will be pin-for-pin replacement for the popular Harris' HA4602 quad op amp (rated to 125°C) that is commonly used in many commercial logging tools. (See enclosed progress report.)

Problems

* Packaging problems above 400°C still plague the Integrated Thermionic Circuit (ITC) project at Los Alamos Scientific Laboratory (LASL). ITC package development has been a joint effort with LASL and Sandia. In order to obtain workable, complete ITC units, the temperature specification may be lowered to 350°C maximum; this action would still fulfill almost all the geothermal needs and it may help this project to achieve a complete working package that could be commercialized.

* The latest high temperature resistor materials developed by Cermalloy still yield thick film resistors that have a +200 ppm/°C change in value up to 400°C. Although this material is stable over temperature, the temperature coefficient of resistance goal, of less than +50 ppm/°C, has still not been achieved.

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Phone (505) 264-9162
FTS 475-9162

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B. Meetings

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Steering Committee Meeting

Integrated Thermionic Circuits

Geothermal Resources Council's 1979 Annual Meeting

A. Subcontracts

Geothermal Cable Development - This contract is for the development of a metal sheath type cable suitable for geothermal well logging operation. Certain contractual questions are still being addressed by the prospective contractors in response to Sandia's review of their proposals. Contract startup is now anticipated for late November or December.

300°C IC Op Amp - Harris Semiconductor in Melbourne, Florida, has started on the development of a 300°C dielectrically isolated, integrated circuit operational amplifier under a Sandia subcontract. This circuit will be a pin-for-pin replacement for Harris' popular HA4602 quad op amp. Although reported herein, this subcontract is funded through Sandia by DOE's Division of Fossil Fuel Extraction.

Gallium Arsenide Diodes - McDonnell Douglas has done a very good job in honoring their contractual obligations. Their final report is detailed enough to allow further devices to be manufactured by any qualified person.

This work should be put to use, meaning continued effort to clear up several rough spots. The delivered devices should be studied further and hopefully put to use in real applications.

These are some of the questions left unanswered by their final report:

1. How can we solve the forward series resistance problem?

2. Why do conventional GaAs diodes follow bulk leakage, while those manufactured for high temperature diodes seem to be dominated by surface leakage.

3. What needs to be done to further the reliability and maximum temperature?

B. Meetings

High Temperature Electronics and Instrumentation Seminar - This two day seminar is planned for December 3 and 4, 1979, at the Marriott-Astrodome Hotel in Houston, Texas. The seminar's objectives are to transfer high temperature electronics and instrumentation technology to industry and to stimulate commercialization by bringing together potential developers, suppliers, and users. Technical sessions will cover a range of topics from electronic devices and hybrid circuits to materials and cables. Logistics will be handled through the University of Houston's Professor Richard Simpson.

Steering Committee Meeting - The next Steering Committee Meeting for this program will be held on December 5, 1979, at the Marriott-Astrodome Hotel in Houston, Texas. This will be a brief meeting since it immediately follows the above seminar. The primary topics to be covered include fracture mapping instrumentation and field testing, pressure transducer development, and a review of this program relative to the program plan published in August 1978.

Integrated Thermionic Circuits (ITC) - On September 18, 1979, Mr. Byron McCormick, Project Manager for Los Alamos Scientific Laboratory's ITC development, visited Sandia to meet with Drs. Bob Eagan, Cliff Ballard, and Tony Veneruso to discuss ITC development in FY80. Sandia has been working on the development of a glass/ceramic package for the ITC while LASL has been investigating a glass/metal package with Ceramaseal Incorporated. In the coming months, the ITC project will focus on producing a working model operable up to the 350-400°C range. There were numerous problems with the package's pin seals, vacuum integrity, welds, and material resistivity at temperatures above 400°C. By lowering the ITC's temperature specification, it is hoped that a complete ITC package can be successfully built and tested. Operation up to the 350°C to 400°C temperature regime will still satisfy all the requirements for geothermal application.

Geothermal Resources Council's 1979 Annual Meeting - Sandia had a number of inputs to this meeting that was held in Reno, Nevada during September 24-27, 1979. Tony Veneruso presented a paper entitled "High Temperature Instrumentation Development and Commercialization for Geothermal Applications" authored by A. F. Veneruso and H. M. Stoller. Joe Coquat had a paper published in the transactions entitled "Cablehead Assembly for Hostile Environment Well Logging." There was also a Sandia exhibit that displayed the electronics, transducers, prototype tools, cables and cableheads that have been developed and field tested to 275°C in geothermal wells. The meeting transactions are available through the Geothermal Resources Council, P. O. Box 98, Davis, California 95616.

II. Internal R&D

A. High Temperature Components

1. Passive Electronic

2. Prototype Production

3. Technology Transfer

A. High Temperature Components

Objective - Develop and commercialize the high temperature electronic components technology industry requires to build geothermal borehole instruments for operation up to 275°C in the near term and 350°C in the long term.

1. Passive Electronic Devices - D. W. Palmer (505) 264-2138

Fabrication of 4000 pF capacitors for the Teledyne Philbrick voltage/frequency hybrids has been completed. The capacitors are stable and change ±1.5°% between room temperature and 300°C.

High temperature resistor materials developed by Cermalloy (931 HT, 941 HT) were used to fabricate thick film resistor patterns. Tests to 400°C indicate that the basic +200 ppm/°C change apparent in previous resistor compositions has not been conquered. However, stability at 400°C and during temperature cycles was good.

2. Prototype Production - D. W. Palmer (505) 264-2138

Evaluation on the first voltage regulators delivered by Teledyne Philbrick has begun. Short-term stability, cyclability, and output temperature coefficient are all within specification. Aging tests have been inconclusive due to poor plating on the original printed circuit mother board. New boards have been made and further testing initiated.

Software and hardware to allow computer control of the voltage regulator oven tests have been prepared. With deliveries of 50 devices from Teledyne it is necessary to go into a semi-automatic test procedure.

Thick film printing and resistor trimming on voltage regulator hybrids were performed at Sandia to provide assistance to Teledyne because of production equipment problems.

3. Technology Transfer - D. W. Palmer (505) 264-2138

The display board featuring high temperature components and hybridization was well received at the annual Geothermal Resources Council meeting in Reno, Nevada, during September 24 -26, 1979. A high percentage of attendees requested purchase information on the high temperature hybrids in the display. Such interest indicates a ready market for commercialization.

Contract extension discussions and paperwork continued on several of the high temperature electronics contracts.

III. External R&D

Arizona, University

Clemson University

Harris Semiconductor

Purdue University

Teledyne Philbrick

Texas A&M University

▸Subject:	High Temperature Thin Film Development
Contractor:	Arizona, University of (E. E. Department)
Principal Investigators:	L. S. Raymond and Prof. D. J. Hamilton Phone (602) 884-1802
Sandia Tech. Monitor:	Bruce Draper Phone (505) 264-2132
Contract Duration:	December 12, 1978 to September 30, 1979
Contract No:	13-2390

Objective - Develop and supply refractory thin film resistors, capacitors, and conductor interconnections for high temperature hybrid, integrated thermionic, and integrated silicon circuits. Assist Sandia in modelling and testing high temperature silicon MOS transistors.

Status - Final report is being prepared.

▸Subject: High Temperature Operation of Silicon Integrated Circuits

Contractor: Clemson University (E. E . Dept.)

Principal Investigator: Prof. J. Prince
Phone (803) 656-3371

Sandia Tech. Monitor: Bruce Draper
Phone (505) 264-2132

Contract Duration: November 15, 1978 to December 31, 1979

Contract No: 13-0326

Objective - Characterize commercial silicon ICs up to 300°C. Correlate these test results in order to produce design rules for high temperature ICs.

Status - Characterization of the ion-implanted/diffused resistors has been completed. 1000 Ω/□ resistors show an increase in resistance from room temperature to 175°C and a sharp decrease from 175 to 275°C. 250 Ω/□ resistors increase their value monotonically from room temperature to 250°C, where they begin to show signs of a zero TCR region.

Substrate fed I^2L (both ring oscillators and individual gates) was found to be functional at 200°C, marginal at 250°C, and not functional at 260°C. Two factors may be contributing to this failure: excessive transistor leakage currents and low base-emitter voltages.

At one week into the 300°C chrome-silicide resistor life test, no change in resistance has been observed.

▶Subject: Development of 300°C OP-AMP

Contractor: Harris Semiconductor

Principal Investigator: J. D. Beasom
Phone (305) 724-7567

Sandia Tech. Monitor: Bruce Draper
Phone (505) 264-2132

Contract Duration: July 11, 1979 to December 31, 1980

Contract No: 13-9425

Objective - Develop a silicon, dielectrically isolated op-amp that will function up to 300°C with performance specifications and external wiring as close as possible to the more conventional HA4602 quad op amp.

Status - Data has been taken on diffused resistors and NPN and PNP transistors up to about 280°C. The resistance change for the resistors was monitored. V_{BE} and I_B have been measured on the transistor at emitter currents of 1 μA, 10 μA, 100 μA, and 1 mA for collector-base voltages of 0 V, 1 V, 5 V, 10 V, 24 V, and 30 V. This data is being reduced at present and should provide large and small signal parameter data for computer models to be used in the design phase. Leakage data shows that PNP collector-base leakage currents are higher than those in NPN structures. It also appears that in both NPN and PNP transistors at high temperatures and low bias currents the base-emitter junction becomes reverse biased when collector voltage is applied.

A test mask set for experimental interconnect evaluation has been laid out and is currently undergoing final revision prior to fabrication. The purpose of this is to evaluate contact resistance, possible migration effects at contacts, and current carrying capacity for the interconnect systems.

▸Subject: High Temperature Thick Film Development

Contractor: Purdue University (Materials & Electrical Engineering Depts)

Principal Investigator: Prof. R. W. Vest
Phone (317) 749-6244

Sandia Tech. Monitor: David W. Palmer
Phone (505) 264-2138

Contract Duration: November 1978 to September 1979

Contract No: 13-0320

Objective - Develop ceramic thick film materials (conductive, resistive, dielectric, and semiconducting) which retain useful electrical and mechanical characteristics for both extended periods (10^5 h) at 300°C and short periods (1000 h) at 500°C.

Status - Resistors--a firing temperature of 1000°C for the low end member (100 Ω/□) resistor ink reported last month (29.7 wt % RuO_2 in Frit 2A) gave resistances as low as 40 Ω/□. Development of a new ink (26.3 wt % RuO_2 in Frit 2A) gave resistances down to 78 Ω/□ when fired at 1000°C. Storage tests of this new ink gave an R/Ro of .976 after 329 hrs at 500°C, and a TCR of 280 ppm/°C for the fully developed (lowest R) microstructure resistors. Resistors without a fully developed microstructure gave an R/Ro of .968 after 329 hrs at 500°C, and a TCR average of 780 ppm. In fully developing the resistor's microstructure both R/Ro and TCR were reduced.

Optimum alumina content for the low k dielectric--formulations containing 5, 25, and 50 w/o Al_2O_3 relative to Frit 2A were tested, and only the 25 w/o Al_2O_3 content ink produced satisfactory capacitors. All of the Al_2O_3 dissolved in the glass during processing of the 5 w/o Al_2O_3 formulation, and a severe pinhole problem was observed with the 50 w/o Al_2O_3 formulation. Several thick film capacitors were fabricated with gold electrodes and the 25 w/o Al_2O_3 + Frit 2A dielectric; measurements showed a 1 kHz dielectric constant that changed from 7.47 at room temperature to 8.32 at 350°C. At 350°C the dielectric constant ranged from 9.72 at 100 Hz to 7.89 at 10 kHz. The dielectric constant as a function of DC bias voltage was measured at room temperature, and no change was observed up to 100 VDC. The DC resistivity of these capacitors was 9×10^{10} Ω-cm at room temperature. Investigations of a medium k dielectric thick film capacitor were initiated with a composition of 36 v/o Frit 2A - 24 v/o $SiTiO_3$ - 40 v/o $Bi_4Ti_3O_{12}$ based on the results of computer modelling. Thick film capacitors with a room temperature dielectric constant of approximately 94 and a DC resistivity from 2×10^9 to 2×10^{11} Ω-cm were made.

▸Subject:	Commercial Production of 300°C Hybrid Microcircuits
Contractor:	Teledyne Philbrick
Principal Engineers:	M. Reagan and R. Cook Phone (617) 329-1600
Sandia Tech. Monitor:	Richard C. Heckman Phone (505) 264-5446
Contract Duration:	October 20, 1978 to September 30, 1979
Contract No.:	13-0338

Objective - Production of 50 high temperature hybrid microcircuit versions of Sandia designed and prototyped 25 to 300°C voltage regulators. This effort is to include further miniaturization and improved hermeticity from Sandia's original prototypes.

Status - Four complete 275°C voltage regulators passed final testing and were handed over to D. Palmer and R. Heckman of Sandia on September 14.

A new method for parts characterization was implemented, based on chip carriers. A test fixutre for this use was built and part characterization begun. An order of magnitude increase in through-put has been achieved.

A large number of voltage regulator substrates were fabricated and work is continuing to complete the quantity required by the deadline. Work was also started on the fabrication of the add-on chip resistors.

▸Subject: High Temperature Magnetic Materials

Contractor: Texas A&M University (E. E. Dept.)

Principal Investigator: Dr. R. K. Pandey
Phone (713) 845-7441

Sandia Tech. Monitor: David W. Palmer
Phone (505) 264-2138

Contract Duration: December 15, 1978 to September 30, 1979

Contract No: 13-0321

Objective - Measure magnetic properties of commercially available soft and hard materials from 25 to 400°C. Complete a literature search for promising developmental high temperature magnetic materials.

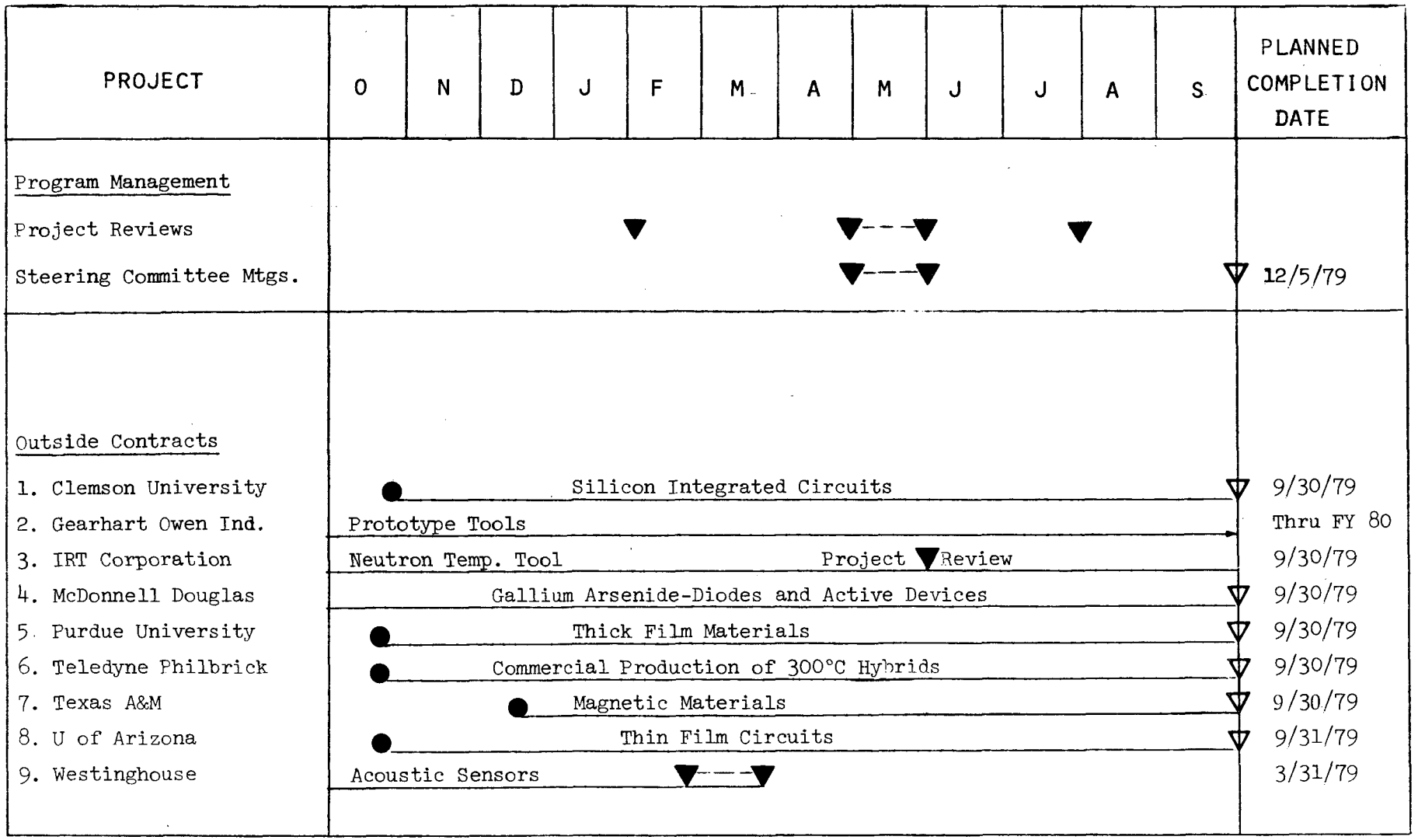
Status - Sample studied: 2 V Permendur (49% Co + 49% Fe + 2% V) supplied by Arnold Engineering Co.

1. Annealing of this sample at 450°C for over 1000 hours has been completed. Measurements of magnetic parameters both in heating and cooling cycles have been done. Moreover, we are also measuring the resistivity of 2 V Permendur as a function of temperature and annealing. Another sample of 2 V Permendur has been prepared and is being annealed at 450°C and we intend to anneal it for 1000 hours without interruption. At intervals of approximately 24 hours, the B-H loops are traced to find out when exactly the sample achieves its magnetic stability. The results will be reported at a later time.

2. During the last few days we have also started the studies on an amorphous magnetic material supplied by Allied Chemicals. Its trade name is 2826 MB and its chemical composition is: $Fe_{40}Ni_{38}B_{18}Mo_4$. This material is supposed to be useful for power transformer.

GEOTHERMAL LOGGING DEVELOPMENT PROGRAM

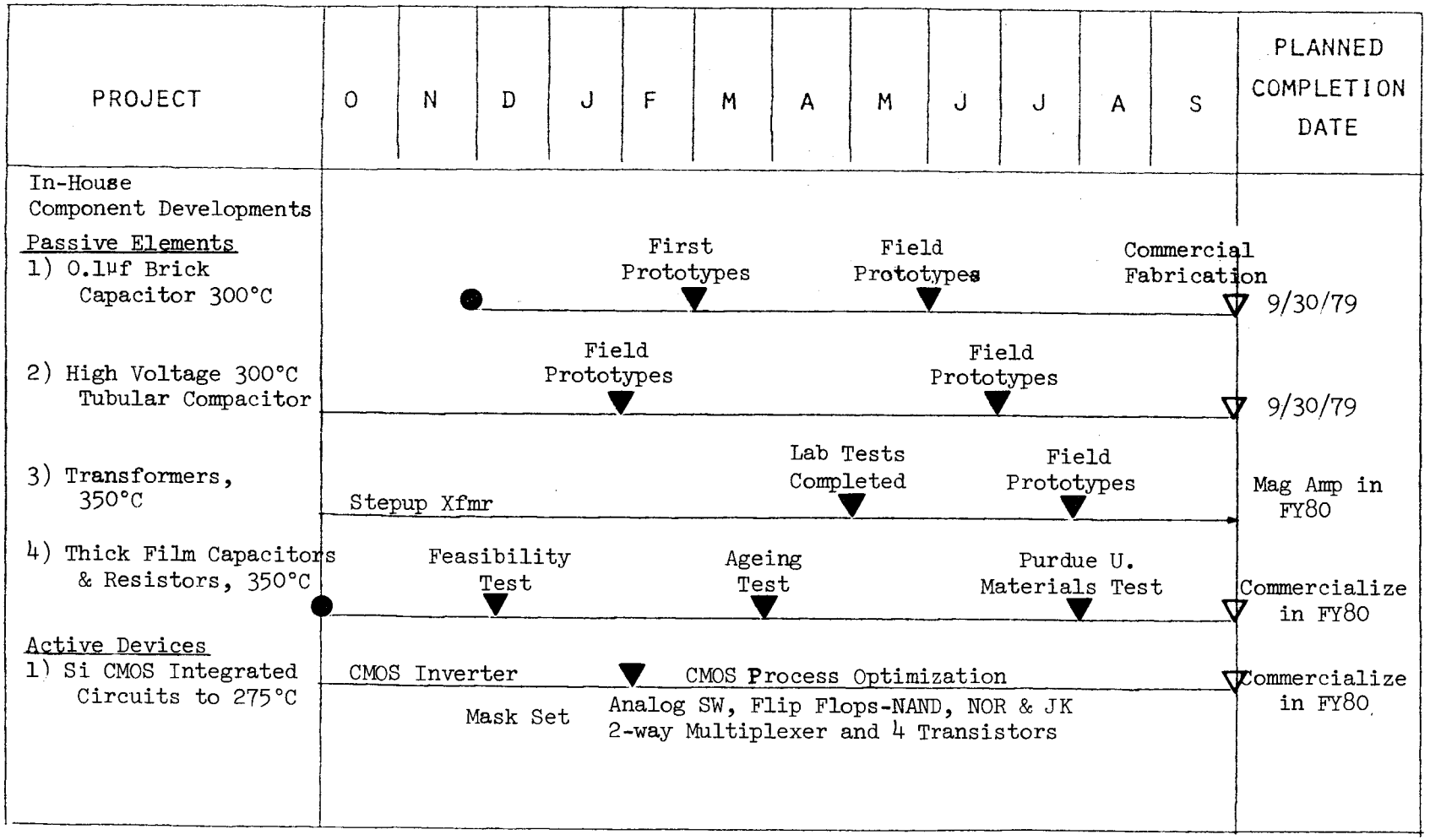
FISCAL YEAR 79



LEGEND: _____ ACTIVITY - - - - RESCHEDULED ○ PLANNED START ● STARTED ▽ PLANNED COMPLETION ▼ COMPLETED

GEOTHERMAL LOGGING DEVELOPMENT PROGRAM

FISCAL YEAR 79



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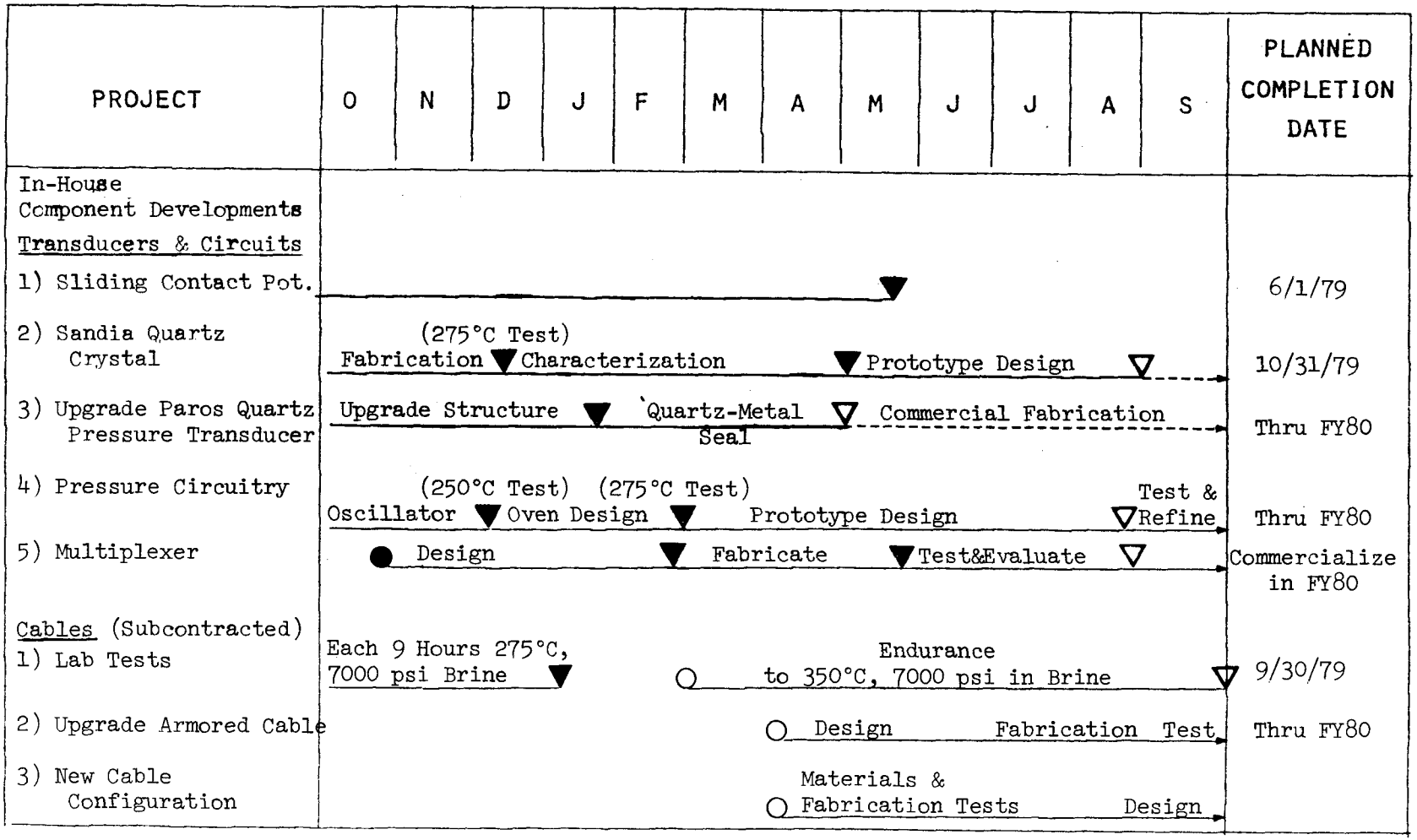
---------- RESCHEDULED ● STARTED ▼ COMPLETED

GEOTHERMAL LOGGING DEVELOPMENT PROGRAM

FISCAL YEAR 79

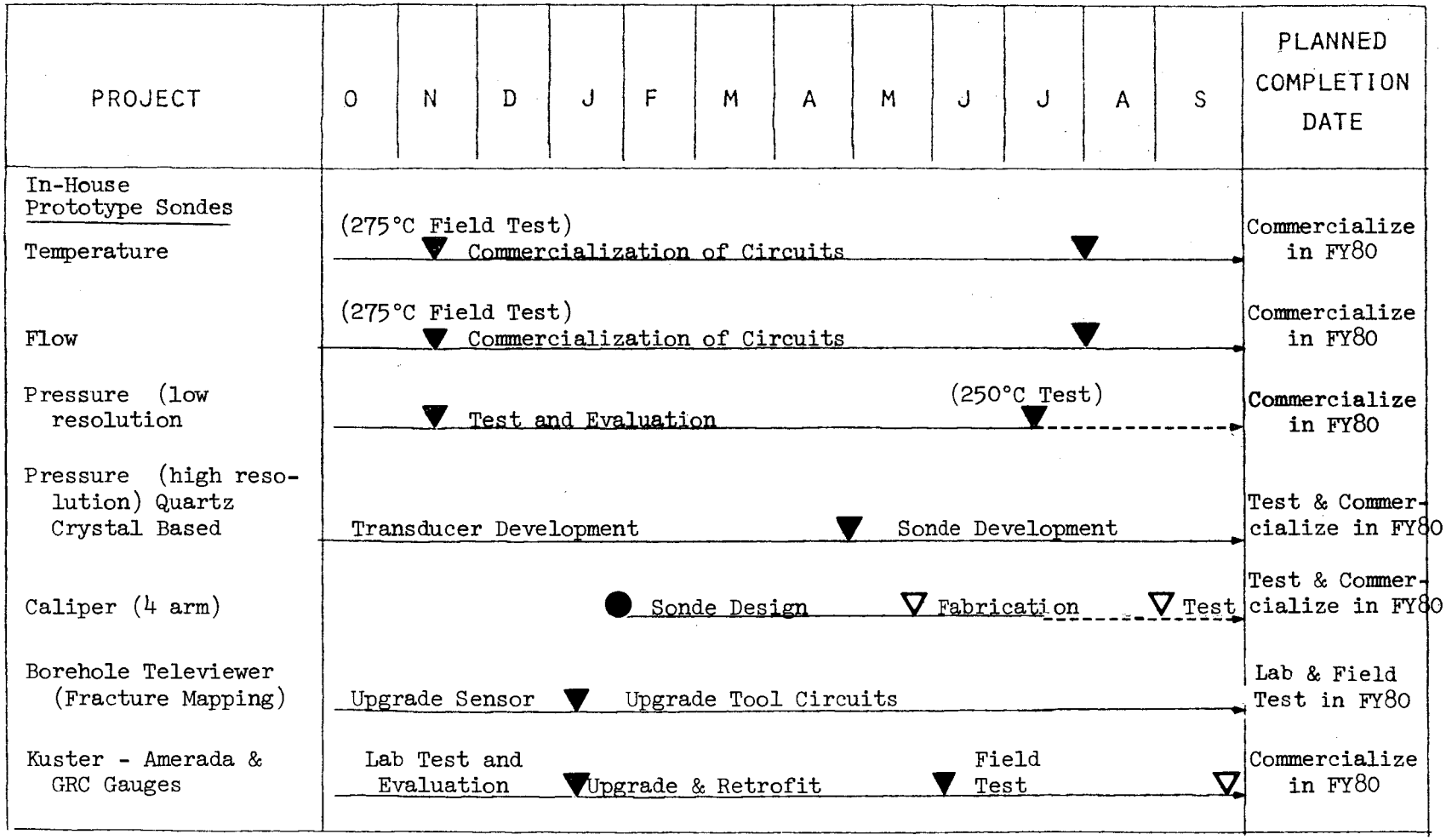


LEGEND: _____ ACTIVITY ○ PLANNED START ▽ PLANNED COMPLETION

---------- RESCHEDULED ● STARTED ▼ COMPLETED

GEOTHERMAL LOGGING DEVELOPMENT PROGRAM

FISCAL YEAR 79



LEGEND: _____ ACTIVITY ○ PLANNED START ▽ PLANNED COMPLETION

---------- RESCHEDULED ● STARTED ▼ COMPLETED

GEOTHERMAL LOGGING DEVELOPMENT PROGRAM

FISCAL YEAR 79

PROJECT	O	N	D	J	F	M	A	M	J	J	A	S	PLANNED COMPLETION DATE
Field Testing													
1) with Union Geothermal at Valles Caldera, NM 275°C Temperature, Pressure and Flow		▼											
2) with Denver Research Institute's Temperature and Pressure Probe plus Sandia's Flow and Pressure Sondes at East Mesa, CA 160°C					○ Well cleanout unsuccessful, workover rig required					● ▼			7/30/79
3) with Republic Geothermal at El Centro, CA, improved Kuster Tools										● ▼			7/30/79
4) with Union Geothermal at Valles Caldera, NM. 275°C Improved Kuster Tools and Sandia's Temperature, Pressure and Flow Sondes												○	Additional tests will be performed in FY80 with commercially fabricated tools

LEGEND: _____ ACTIVITY - - - - RESCHEDULED ○ PLANNED START ● STARTED ▽ PLANNED COMPLETION ▼ COMPLETED

FORM ERDA 536
(2/1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

FORM APPROVED
OMB NO. 38-R

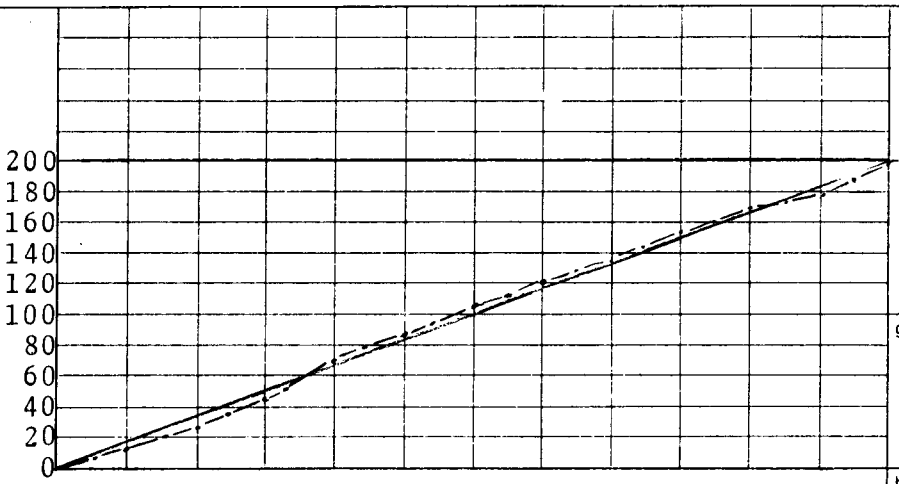
1. Contract Identification	2. Reporting Period	3. Contract Number
Geothermal Logging - Program Management	9-1 through 9-30	

4. Contractor (name and address)	5. Contract Start Date	6. Contract Completion Date
Sandia Laboratories, Division 4736 Albuquerque, New Mexico 87115	1 Oct 1978	30 Sept 1979

7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 79

9. Cost Status

a. Dollars (in thousands)



B&R Number
AE-30-01-05

e. Actual Costs Prior FYs

f. Planned Costs Prior FYs

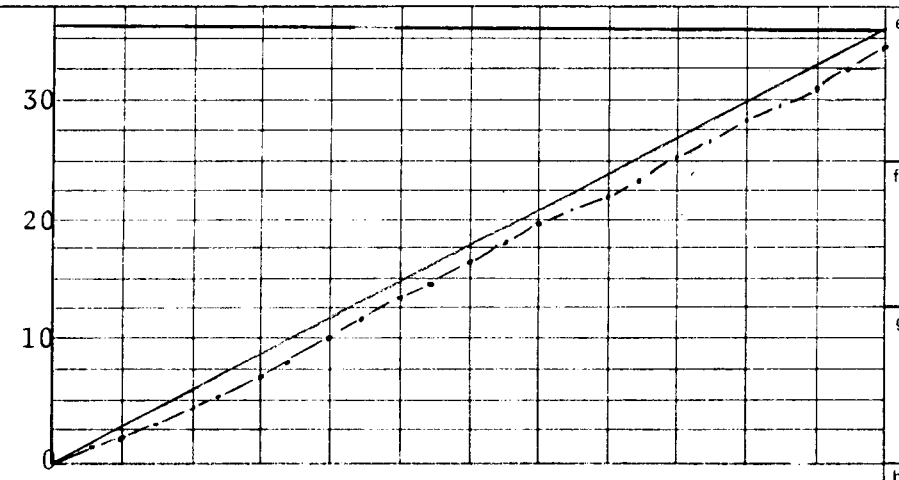
g. Total Estimated Accrued Costs for Contract: $200,000

h. Total Contract Value: $200,000

Accrued Costs													
b. Planned	15	30	47	64	81	98	115	132	149	166	183	200	
c. Actual	14	27	45	65	83	105	121	136	154	167	179	198	
d. Variance	-1	-3	-2	+1	+2	+7	+6	+4	+5	+1	-4	-2	

10. Manpower Status

a. Man Months



e. Actual Manpower Prior FYs

f. Planned Manpower Prior FYs

g. Total Estimated Manpower for Contract: 36

h. Total Contract Manpower: 36

Manpower													
b. Planned	3	6	9	12	15	18	21	24	27	30	33	36	
c. Actual	2.0	4.1	7	10	13	15.9	19.1	22.3	25.4	28.2	30.6	34	
d. Variance	-1	-1.9	-2	-2	-2	-2.1	-.9	-1.7	-1.6	-1.8	-2.4	-2	

FORM ERDA 536
(2/1/77)

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT MANAGEMENT SUMMARY REPORT

FORM APPROVED
OMB NO. 16-R

1. Contract Identification	2. Reporting Period	3. Contract Number
Geothermal Logging Development - In House R&D	9-1 through 9-30	
4. Contractor (name and address)		**5. Contract Start Date**
Sandia Laboratories, Division 4736 Albuquerque, New Mexico 87115		1 Oct 1978
		6. Contract Completion Date
		30 Sept 1979

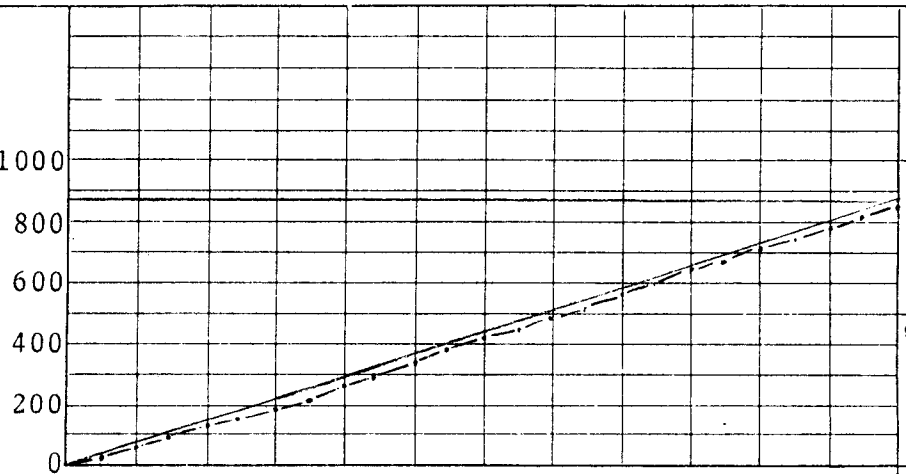
7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 79

9. Cost Status

a. Dollars (in thousands)

_____Planned
__.__.__.Actual

B&R Number
AE-30-01-05



e. Actual Costs Prior FYs

f. Planned Costs Prior FYs

g. Total Estimated Accrued Costs for Contract

$866,000

h. Total Contract Value

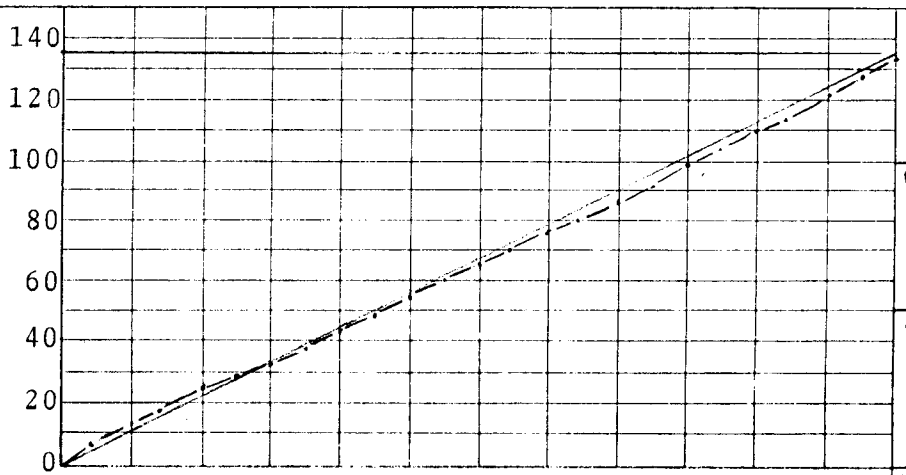
$866,000

Accrued Costs	O	N	D	J	F	M	A	M	J	J	A	S
b. Planned	72	144	216	288	360	432	504	576	648	720	790	866
c. Actual	64	130	193	264	338	410	489	561	632	710	781	842
d. Variance	-8	-6	-23	-24	-22	-22	-15	-15	-16	-10	-11	-24

10. Manpower Status

a. Man Months

_____Planned
__.__.__.Actual



e. Actual Manpower Prior FYs

f. Planned Manpower Prior FYs

g. Total Estimated Manpower for Contract

136

h. Total Contract Manpower

136

Manpower	O	N	D	J	F	M	A	M	J	J	A	S
b. Planned	11.3	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7	113	124.5	136
c. Actual	11.6	23.1	32.7	44.6	55.5	66.3	77.6	87.8	98.9	110	120.3	133.2
d. Variance	+.3	+.5	-1.2	-.6	-1.0	-1.5	-1.5	-2.6	-2.8	-3	-4.2	-2.8

FORM ERDA 536
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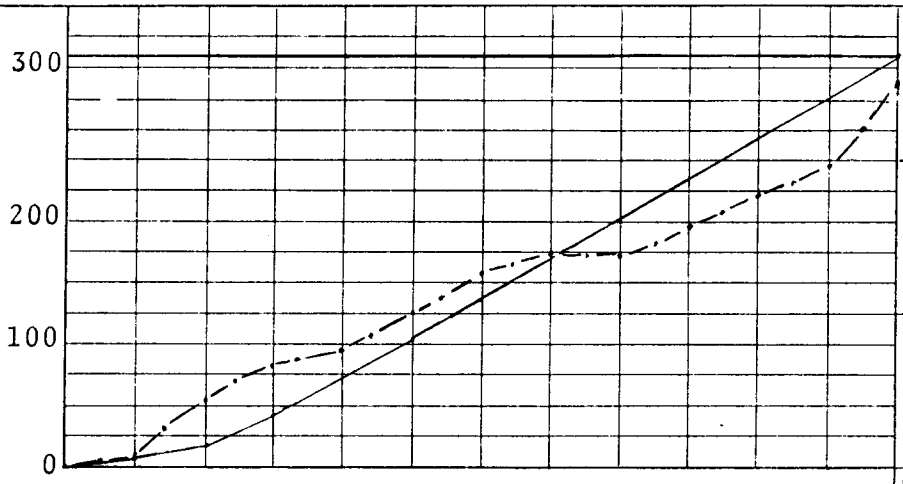
1. Contract Identification	2. Reporting Period	3. Contract Number
Geothermal Logging - External R&D	9-1 through 9-30	
4. Contractor (name and address)		**5. Contract Start Date**
Sandia Laboratories, Division 4736 Albuquerque, New Mexico 87115		1 Oct 1978
		6. Contract Completion Date 30 Sept 1979

7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 79

9. Cost Status

a.



B&R Number
AE-30-01-05

e. Actual Costs Prior FYs

f. Planned Costs Prior FYs

g. Total Estimated Accrued Costs for Contract

$329,000

h. Total Contract Value

$329,000

Accrued Costs	O	N	D	J	F	M	A	M	J	J	A	S
b. Planned	5	15	41	73	105	137	169	201	233	265	297	329
c. Actual	5	54	80	94	125	158	172	174	199	228	244	312
d. Variance	0	+39	+39	+21	+20	+21	+3	-27	-34	-37	-53	-17

FORM ERDA 536
(2/1/77)

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4. Contractor (name and address)		**5. Contract Start Date**
Sandia Laboratories - Division 4736 Albuquerque, New Mexico 87115		1 Oct 1978
		6. Contract Completion Date
		30 Sept 1979

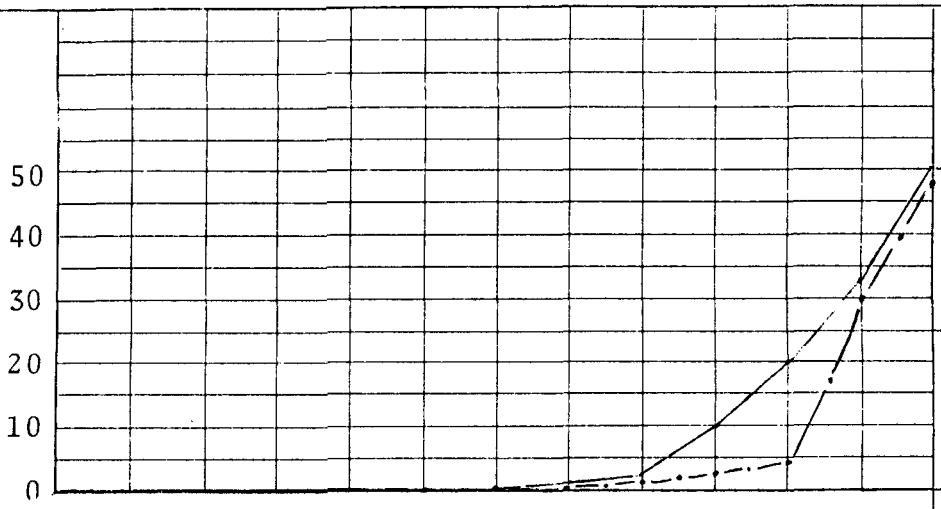
7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 79

9. Cost Status — Total Costs

a. Dollars (in thousands)

_____ Planned

__.__.__. Actual



B&R Number
AE-30-01-04

e. Actual Costs Prior FYs

f. Planned Costs Prior FYs

g. Total Estimated Accrued Costs for Contract

$50,000

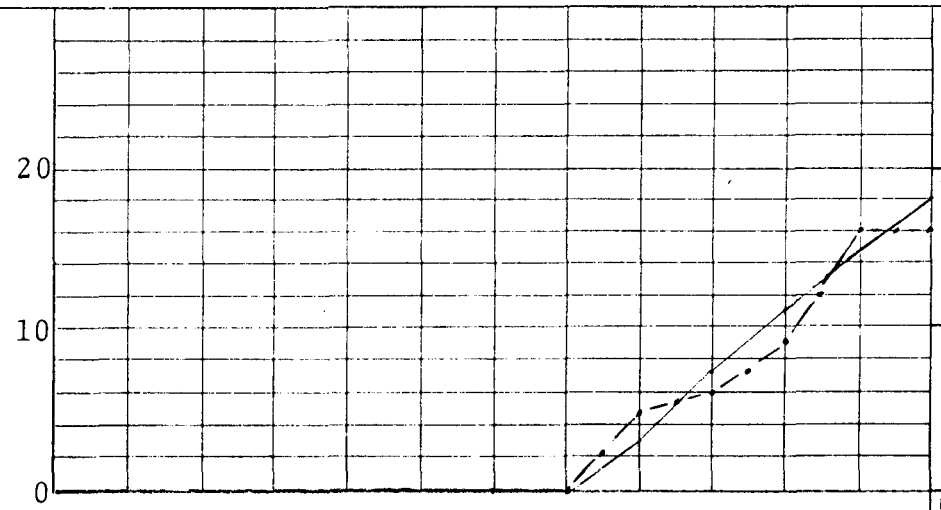
h. Total Contract Value

$50,000

Accrued Costs													
	b. Planned	0	0	0	0	0	1	3	10	10	20	33	50
	c. Actual	0	0	0	0	0	0	1	8	10	18	30	47
	d. Variance	0	0	0	0	0	-1	-2	-2	0	-2	-3	-3

10. Cost Status - In House Costs

a.



e. Actual costs Prior FYs

f. Planned costs Prior FYs

g. Total Estimated costs for Contract

$18,000

h. Total Project Costs

$18,000

Accrued Costs													
	b. Planned	0	0	0	0	0	0	0	3	7	11	15	18
	c. Actual	0	0	0	0	0	0	0	5	6	9	16	16
	d. Variance	0	0	0	0	0	0	0	+2	-1	-2	+1	-2

Distribution:

DOE/ALO	W. McMullen
DOE/ALO	D. Nowlin
DOE/ALO	A. Wilbur
DOE/CHI	B. Mueller
DOE/DGE	C. Carwile
DOE/DGE	B. DiBona
DOE/DGE	A. Follett
DOE/DGE	A. Jelacic
DOE/DGE	R. LaSala
DOE/DGE	C. McFarland
DOE/DGE	R. Reeber
DOE/DGE	M. Skalka
DOE/DGE	J. Salisbury
DOE/DGE	G. Stafford
DOE/NEV	R. Clarke
DOE/SAN	A. Adduci
DOE/SAN	M. Molloy
2117	V. A. Wells
2150	T. L. Workman
2151	R. C. Heckman, Attn: B. L. Draper
2151	D. W. Palmer, Attn: K. R. White
2155	G. W. Krause, Attn: J. D. McBrayer
4700	J. H. Scott
4730	H. M. Stoller
4730	A. J. Caldwell
4733	C. L. Schuster
4737	B. E. Bader, Attn: R. L. Fox
4740	R. K. Traeger
4741	S. G. Varnado
4742	A. F. Veneruso
4742	T. J. Bauman
4742	P. A. Bonn
4742	J. A. Coquat
4742	F. E. Heard
4742	R. W. Eifert
4742	B. H. Major
4742	T. D. McConnell
4743	H. C. Hardee
4744	H. M. Dodd
4744	J. Polito
4744	C. C. Carson
5811	C. Arnold
5845	R. J. Eagan, Attn: C. P. Ballard